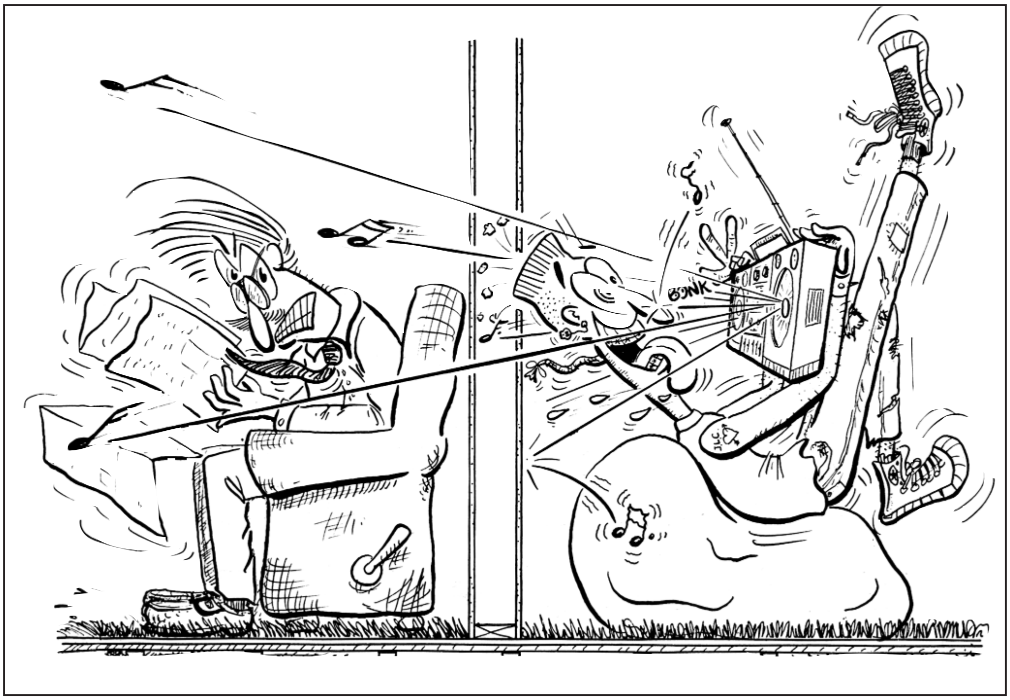
Retrofit Sound Control



To block sound, you don't need materials with superpower — just the right combinations of conventional components

by Jerry Germer

Your client wants you to soundproof his end bedroom so that he can use it as a home office. His teenage son is prone to blasting U2 over his boom box from the adjacent bedroom. Even when "turned down," enough sound penetrates the office room to make concentration tough. Can you solve the problem without permanently shutting down the power to the son's bedroom or rebuilding the house?

Noise control in multi-family housing has always tested the mettle of builders and designers. Today, changes in families and lifestyles are making sound control a problem in single-family homes as well.

What's All That Noise?

Before talking about control, we need to know what we mean by "noise," "sound," and "control." Simply put, sound is what we want to hear and noise is what we want to shut out. Speech can be either, by this way of thinking. An air conditioner makes noise — but its soft, constant hum in the background probably helps mask more objectionable noises, such as intermittent traffic noise from outside. To most people, noise has certain things in common:

- It's loud enough to be uncomfortable.
- It's high- rather than low-pitched.
- It's intermittent rather than continuous.
- It's more likely a pure tone (single frequency) than several tones of different frequencies (tuning fork vs. a passing car).

Because retrofit options are limited and more costly than building sound control into new construction, it pays to know what you are doing. Before proposing a fix, get a precise idea of the client's problem. "My house is too noisy" isn't precise. "I'm disturbed in the downstairs den by people walking on the floor above" is.

How Sound Is Heard

Acoustics, never a simple science, is made more slippery by the way people perceive sound. Basically, sound is created by vibrating matter. A person speaks in one room, causing pressure waves to travel through the air like ripples on a pond. When these pressure waves strike a wall, the wall vibrates, causing air pressure waves on the other side of the wall. These waves strike the ears of a person and are heard, if the frequency is in the range of 20 to 20,000 cycles per second (Hz) and the person has a pair of healthy, young ears. With age and exposure to loud noise over a prolonged period come a marked decrease in hearing in the high frequencies.

A person in one room hearing a person talking in a second room is an example of "airborne" sound transmission. Another type, "structure-borne" sound, is caused by the direct impact against the structure by people or equipment, such as doors slamming in walls, pipes rattling floors

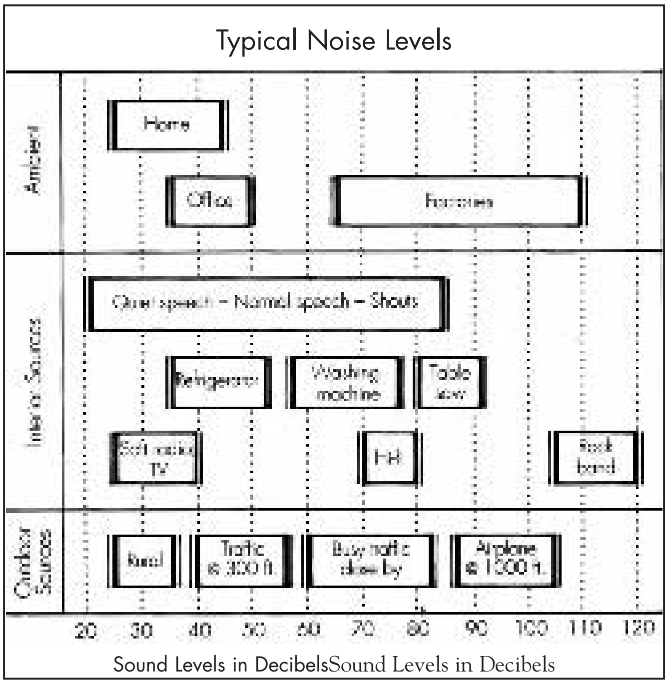


Figure 1. *Levels of loudness (in decibels) are shown for several typical noises. We perceive sound below 10 decibels as very quiet and sound at about 110 decibels with increasing discomfort. At 120 decibels, the sound is deafening.*

or walls, or people walking on floors.

Loudness, or intensity level, is measured in decibels (db). Because decibels are logarithmic, each increase of 10db is ten times more intense than the last level. But we hear the difference as only twice as loud — 90 decibels sounds twice as loud as 80, which seems twice as loud as 70, and so on. Figure 1 gives an idea of the loudness in db of some common noise sources.

Controlling Sound in Rooms

When you speak inside an empty room that has just been drywalled, the sound carries very well. All surfaces are smooth and hard, so sound bounces off one hard surface and then another until all of the sound energy is absorbed into the structure, which happens slowly.

This acoustically "live" room will get noticeably deader (quieter) when soft-surface finishes (carpets) and furniture are installed. These finishes cut reverberation by absorbing sound waves into their soft, cellular surfaces. The amount of improvement can be calculated, but suffice it to say you get the greatest improvement with the first correction. Carpeting the floor, for instance, will deaden almost any room enough for most people's tastes. Adding porous wall or ceiling finishes will mostly add cost, rather than noticeable sound control.

Controlling the quality of sound within a room is more of an issue in larger buildings with large rooms, such as schools or restaurants, than it is in homes. Most likely, your client's problem is not making a particular room "deader," but cutting down sound passing from one part of the house to another. This is trickier. Unfortunately, simply installing soft, sound-absorbent materials over the surfaces of one room doesn't do much to stem the transmission of airborne sound to another. What's needed is sound isolation — beefing up the sound-stopping qualities of the barriers between rooms.

Rating Sound Barriers

To travel, sound needs a source, a path, and a receptor. The path is the only one of these you can do anything about. Sound, like heat, seeks the easiest path. Airborne sound between rooms travels easiest through air gaps, doors, and solid walls — in that order. Most barriers contain all of these sound paths. In the home office example, the end bedroom has a common wall with the son's bedroom and a doorway to the shared hall; both bedroom and office doors doubtless have gaps around them.

STC ratings. The number of decibels of airborne sound a barrier can reduce is indicated by its Sound Transmission Class (STC). STC ratings, derived from averaging several frequencies, aren't perfect, but they still provide the most useful way to rate a sound barrier for rule-of-thumb accuracy.

A 1968 HUD study, *A Guide to Airborne, Impact, and Structure-borne Noise Control in Multi-family Dwellings*, makes STC recommendations based upon the function of adjacent rooms. As an example, for a bedroom next to another bedroom the recommended STC rating is 52. Next to a living room, the bedroom

Sound Control Materials: What Works, What Doesn't

Improving sound control within and between rooms comes more from using standard materials wisely than finding materials with superpowers. Here are some materials that can help, and some that are often wrongly assumed to work well.

Gypsum wallboard. Gypboard adds mass to walls, which helps reduce airborne sound transmission. Additional layers are much more effective if mounted on resilient supports. Denser fire-rated gypboard (type X) is a better barrier than unrated and costs only slightly more.

Soundboard. These are panels, ½-inch and thicker, made of wood fibers pressed into rigid sheets. Soundboard is better suited to dampening vibration (structure-borne sound) than it is to absorbing airborne sound. Homasote Company (Box 7240, W. Trenton, NJ 08628-0240; 609/883-3300) claims an STC of 50 for a 2x4 stud wall clad with 440 Sound-A-Sote nailed on either side to the studs and covered by ⅝-inch fire-rated drywall glued to the soundboard.

Fiber insulation. Fiberglass and mineral fiber insulation in the wall or floor cavity increases the barrier's resistance to airborne sound. Fiberglass specifically labeled for sound control is best, since it is of slightly higher density than ordinary batts. These start out at an thickness of 1½ inches and run to 3½ inches thick. Use a size ½ inch smaller than the cavity is deep; this gives maximum absorption, but avoids forming a sonic bridge between the two walls. Blown-in loose fill is somewhat less effective, because it tends to tie the two wall faces together to vibrate as one.

Vermiculite insulation. Loose vermiculite insulation poured into wall cavities does little to stem sound transmission. You'll get better results by blowing in chopped fiberglass or cellulose, better still with batts or blankets.

Rigid foam insulation. Rigid foam insulation inside a wall cavity is practically useless in reducing airborne sound transmission. Mounted on the wall or ceiling surface, however, it will absorb some sound, but this is more effective in changing the room's acoustics than in preventing passage of noise into adjacent rooms. It shouldn't be exposed anyway, of course, because of its lethal off-gassing in case of fire.

Sealants. Any non-hardening sealer will effectively seal cracks and air leaks, reducing the sonically weak points in a barrier. Make sure the sealant is compatible with the materials to be sealed, so that you get a good bond. For best results, use a sealant labeled "Acoustical," such as those made by DAP (Box 277, Dayton, OH 45401; 513/667-4461); USG (550 N. Brand Blvd., Glendale, CA 91203; 818/956-1882); and Tremco (Treuhaft Blvd., Barbourville, KY 40906; 606/546-5181).

Resilient channels. You can boost both STC and IIC ratings by about 5 points by mounting ⅝-inch type-X wallboard over light-gauge metal channels run horizontally across studs at 16-inch or 24-inch centers. With 3½-inch batts in the stud bays, such a system gives an STC rating of 50. The inner flange of the channel screws or nails to the wall studs. When gypsum wallboard is screwed to the outer flange, the channel acts like a spring to absorb vibrations from the wall surface. Make sure your drywall screws are just long enough to penetrate the drywall and into the channel flange, but not into the studs, which would compromise the sound-absorbing resilient effect.

Gasketing. Bulb or magnetic type gaskets make good sound seals around windows and doors. Pemko (4226 Transport St., Venture, CA 93003; 805/642-2600) and Krieger Steel Products (4896 Gregg Rd., Pico Rivera, CA 90660; 213/695-0645) make seals specifically for sound control. *—J.G.*

should have a rating of 54; next to a kitchen, 55; and next to a family room, 56 (see Table 1). The STC number for the barrier is meant as a total, or composite, number that includes the leakiest paths — cracks and doors — as well as the wall or floor. To give an idea of what the numbers mean, see Table 2.

Table 1: Recommended STC for Bedroom Partition Walls

Adjacent Room	STC
Bedroom	52
Living Room	54
Kitchen	55
Family Room	56
Hall	52

Note: *These ratings were taken from* A Guide to Airborne, Impact, and Structure-borne Noise Control in Multi-family Dwellings *(HUD, 1968). No guides have been published for single-family dwellings.*

A typical residential interior wall — 2x4 studs at 16 inches on-center faced with 1/2-inch drywall on each side — is rated around STC 34. To note a significant improvement over the typical interior wall, aim for STCs in the 40 to 50 range. For a professional home office where sound isolation is essential, look for STCs above 50.

Plug the Leaks First

The smallest crack can degrade the sound resistance of a wall system by a surprising amount. For example, if a composite wall (one with a door) 12 feet 6 inches long by 8 feet tall starts out rated at STC 40, an ungasketed 1/16-inch crack around the door will drop the rating to STC 29. Other paths are electrical outlets (particularly if they are positioned back-to-back), switch boxes, telephone outlets, and heating ducts. Sealing these gaps is your first priority in strengthening a sound barrier.

Sealing electrical boxes is relatively simple, if tedious. Many of the same approaches and materials used to seal electrical outlets against air leakage and heat loss are effective in sound control. Install fiberglass insulation behind the box. Then seal all openings in the box and between the box and the wall finish with flexible caulk, such as silicone or polyurethane (see "Sound Control Materials: What Works, What Doesn't"). Pull the outlet or switch out of the box far enough to allow you to reach inside and caulk each hole or gap. To seal the gap between the box and the drywall finish, you'll probably get a better bond with polyurethane or acrylic latex caulk than with silicone.

Table 2: Sound Control Ratings

25	Normal speech can be easily understood.
30	Loud speech can be understood.
35	Loud speech can be heard, but not understood.
42	Loud speech audible as a murmur.
48	Some loud speech barely audible.
50	Loud speech not audible.

Note: *This table gives an indication of what can be heard on the other side of a partition wall with a given STC rating.*

Make sure any cracks between the wall and floor are caulked with an acoustical sealant. Such sealants stay soft and flexible, so they won't crack.

Shared heating ducts between adjacent rooms are a real nuisance. The best — but not easiest — fix is to decouple the ducts and run a separate supply duct from the furnace to the room needing quieting. If you can't do this, lining the ducts with acoustic insulation will absorb some of the airborne sound.

And while you are sniffing out airborne sound paths, don't neglect any recessed lights in the ceiling, if the space above the ceiling communicates with the noisy room. One option is to replace the units with surface-mounted fixtures. Seal the holes in the junction boxes, as with electrical outlets.

Doors — The Next Hurdle

Doorways leak sound through cracks and openings and through the door itself. To seal air paths around doors, use a flexible gasketing similar to what you would use to weatherstrip an outside door. Add either a weatherstripped threshold or other device to seal the crack at the base. If the door has louvers, plug them with a solid panel or replace the door with a solid door.

If gasketing the door won't provide enough sound control, you have to upgrade the door as well. But what is enough? A good rule of thumb for a doorway is to shoot for an STC rating within 10 points of the wall STC number. The effect of a typical interior door on the total barrier is large enough to make the door the first upgrade priority. Standard, ungasketed, hollow-core interior doors are rated at STC 22. Louvers drop this to 15.

Figure 2 shows a number of options for improving a basic door from STC 15 up to STC 55.

The Walls

The more the wall resembles a diaphragm (think of a drum head), the more sound it transmits between rooms. As with a drum head, you break down a wall's diaphragm action by disconnecting it from its supports. You likely can't do this with the primary wall and maintain structural integrity, so look for ways to make any construction added for sound control vibrate separately from the primary wall and the house structure, particularly the floor.

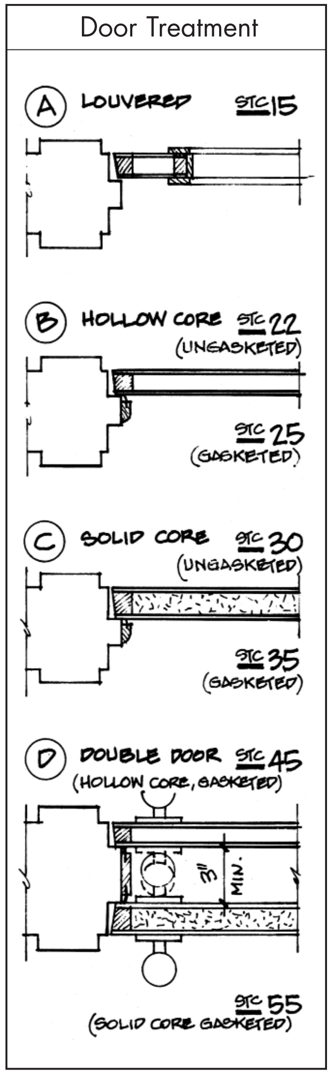


Figure 2. *Doors, the weakest part of the sound barrier between rooms, can be improved from a poor STC rating of 15 to around STC 35 by plugging openings (such as louvers), sealing cracks with gasketing, and replacing hollow-core with solid-core units. Further improvement up to STC 55 requires doubling the door, which probably means fattening the wall as well.*

Options for upgrading walls to control sound transmission basically come down to adding mass (good for stopping low frequencies, less so for high); insulating the cavity; and adding a second wall system independent of the primary wall. Figure 3 shows how a standard 2x4 stud wall can be improved from STC 34 up to STC 59, and gives an approximation of the square foot unit cost for each improvement system.

The cheapest and easiest choice (Figure 3A) is to simply add a layer of drywall to one side, gaining an improvement of 3 decibels. All other measures require the removal of the face layer of drywall from one side of the wall in order to get to the wall core. Adding another layer of drywall on resilient channels directly to the face of the existing drywall is a waste of time, since the resulting air space is too small to effectively separate the two walls, which will still vibrate almost as one. However, a resilient-channel system mounted directly over the studs, with fiberglass acoustic batts in the stud bay

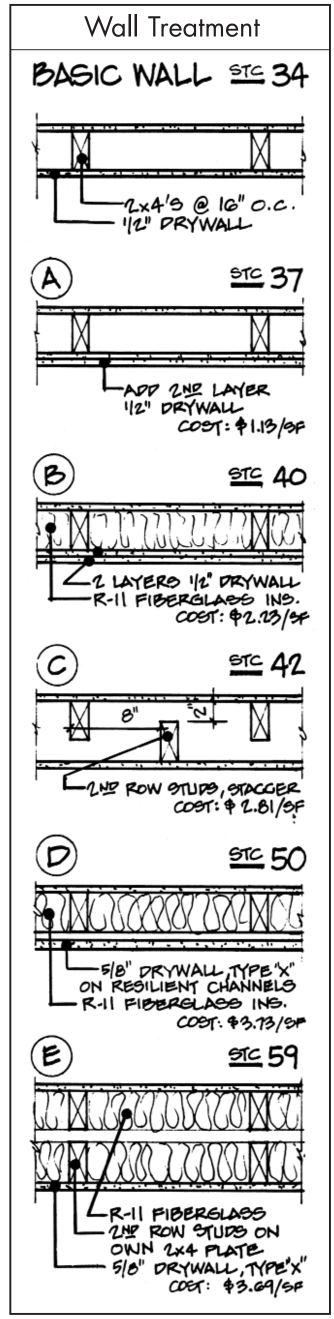


Figure 3. *The airborne sound rating for a standard 2x4 stud wall with 1/2-inch gypsum drywall on each side is about 34 — satisfactory for most room separation requirements. For additional soundproofing, you can upgrade the wall to around STC 59 by altering only one side of the wall. The most ambitious detail (E) requires a separate 2x4 plate and careful attention to caulking the perimeter around the new drywall.*

and fire-rated gypsum board mounted to the channels, can upgrade a typical 2x4 interior wall to STC 59.

Quieting Floors

The STC number for a floor measures only the amount of airborne sound that passes through the system. But floors are also constantly subject to an additional noise, that of impact. Each footfall sets the floor into a sharp, sudden vibration. To measure how well a floor resists this kind of noise, there's another index, the IIC (Impact Isolation Class) rating. You need both the STC and the IIC number to evaluate how much total sound a floor transmits. As with the STC rating, the HUD study recommends IIC ratings based upon the relationship of the stacked rooms. For a bedroom underneath another bedroom, the recommended IIC rating for the floor/ceiling assembly is 52. If the bedroom is under a living room it should have an IIC rating of 57. Below a kitchen, family room, or hall, 62 is required.

Before remodeling a floor, you should define the noise problem. If people walking on the floor above a basement bedroom disturb the sleepers, the problem is structure-borne sound. Without tearing into the floor, you can boost the floor's IIC rating by 12 to 24 decibels by installing a carpet and pad, as shown in Figure 4A. As you would expect, the lower number is for an economical low-pile carpet over a fiber pad, the higher ratings for high-pile carpet over a foam pad.

Alas, adding even a pricey carpet and pad doesn't affect airborne sound transmission, which stays at STC 37 for the floor type shown. If airborne sounds such as speech or music remain a problem, two options remain: floating the floor or suspending the ceiling and adding cavity insulation.

Floating floors. A floating floor yields a separate surface that dampens vibrations to the primary surface, similar to the second-wall option in Figure 3. To make a floating floor, as shown in Figure 4B, nail a layer of 1/2-inch fiberboard to the subfloor. Then loosely lay, but don't secure, 1x3 or 2x4 sleepers over the fiberboard. Then nail a second subfloor to the sleepers. Leave a 3/8-inch gap between the second subfloor and the walls and caulk the joint with acoustical sealant.

Built correctly, such a floating floor raises the STC by 13 decibels and the IIC by 8. One drawback to this approach is the rise in finish floor level — the 2 or 3 extra inches may spell trouble with door clearances.

If you're worried about door clearances, minimize the floor's thickness by using 1x3 sleepers and a 1/2-inch upper subfloor; this will add just under 2 inches total thickness. If the doors are tall, go with 2x4 sleepers, which will make a steadier floor and be easier to hit when nailing the subfloor to them.

Suspend the ceiling. The alternative to a floating floor is a suspended ceiling with insulation. (To both float the floor *and* suspend the ceiling is probably not cost effective: Airborne sound will be reduced, but the suspended ceiling won't curb structure-borne sound significantly more than the floating floor already does.)

There are various ways to suspend a ceiling so that it won't transmit impact vibrations. After removing the existing ceiling, you could add ceiling joists that bear at the walls or are hung from wires from the floor joists. A simpler way is to screw resilient channels to the existing joists as an attachment for the drywall ceiling.

However you frame the ceiling, stuffing the joist cavities with 3 1/2-inch, R-11, acoustical fiberglass insulation will curb impact noise by about 7 decibels.

Floor Treatment

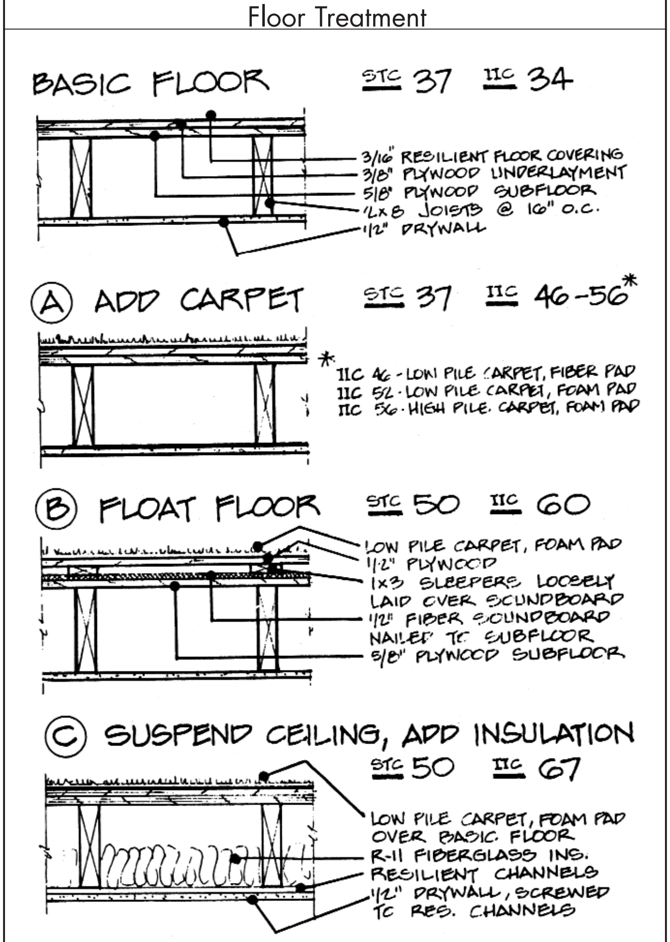


Figure 4. *Floors are subject to both airborne and impact (structure-borne) sound transmission. Simply adding a padded carpet (A) can boost a typical floor's resistance to structure-borne sound from IIC 34 to 56. Further improvements require "floating" the floor (B) or hanging the ceiling below (C).*

Pipe Noise

A common irritation in houses with PVC waste piping is the sudden gushing noise audible downstairs when an upstairs toilet is flushed. Short of the best fix — replacing the PVC pipe with cast iron — look for ways to wrap the pipe in R-11 fiberglass insulation and enclose it in a sealed box, preferably faced in drywall.

Sirens in the Night

None of the measures described so far does anything to thwart noise from outside. The steady din of traffic probably isn't a problem, but honking horns, sirens, and airplanes are. Fortunately, most exterior walls already have pretty good STC numbers, thanks to thermal insulation and several "skin" layers. Figure an STC of 43 for a 2x6 wall with R-19 insulation. Even a 2x4, R-11 wall with wood siding would come in around STC 40.

But windows can form the weak link. A "worst-case" window (unsealed, operable, single-glazed sash window such as shown in Figure 5A) has an STC of 25. Upgrading the same window with weatherstripping and standard double glazing (the minimum improvement for energy conservation) raises the STC to 30. The improvement in STC comes from the gasketing, not the double glazing; panes spaced less than an inch apart do the best weather insulation job, but the small air gap they trap too easily transmits sound vibrations.

Window Treatment

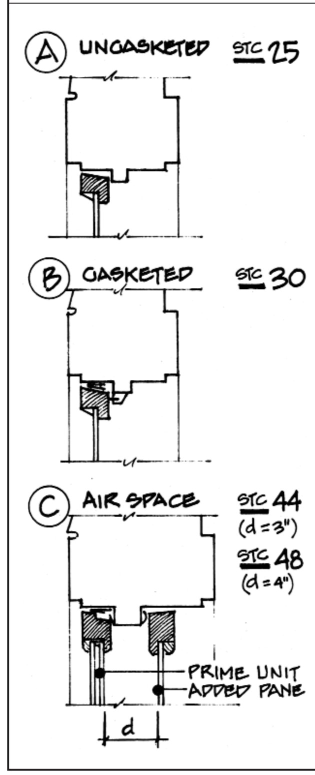


Figure 5. *An ungasketed window (A) is a relatively poor sound barrier, whether the window is single- or double-glazed. Sealing the window (B) improves the STC rating from 25 to 30. Adding a second pane (C) separated by a clear air space of 1 to 4 inches boosts the STC by anywhere from 8 to 23 points.*

To raise the STC significantly, you need to add another pane at least an inch away. Adding a second, separate pane separated by a clear air space of 1 inch boosts the STC by 8 to 10 points; a 2-inch space gets you 11 to 14 STC points; a 3-inch space, 19 points; and a 4-inch space, 23 points. You get these gains whether the original window is single- or double-glazed.

Some manufacturers claim relatively good sound ratings for their windows. Pella's Monumental series (Pella Windows, 102 Main St., Pella, IA 50219; 515/628-1000) and Hurd's new Insol-8 windows (Hurd Millwork, 575 S. Whelen Ave., Medford, WI 54451; 715/748-2011) are both rated at STC 35. ■

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